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Mechanical Properties of Hemp-Reinforced Biomimicked Composites

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Abstract:

Hemp-reinforced biomimicked composites (HRBC) were fabricated and tested under various mechanical testing configurations. The results were compared with the results of similar composites made with and without fiberglass reinforcement. In general, hemp reinforcement increases the tensile and bending strength of the composites. The tensile strength of the HRBC is greater than non-reinforced biomimicked composite (BC). However, this value is smaller than the tensile strength of fiberglass reinforced biomimicked composite (FRBC). The fracture toughness of HRBC was found to be close to that of FRBC, nearly seven times that of monolithic structural material.

Introduction:

Composite materials have been made for structural purposes since the beginning of recorded history. Adding straw to mud to build a stronger wall is an early example of fabrication and use of such composites. Recent use of natural fibers in construction include the use of organic waste fibers, such as sisal, bamboo, or sugar cane to offer stronger building material at lower economic and ecologic costs [5]. Dynamic shear forces of nature including those of earthquakes and hurricanes cause human and property losses which can be mitigated mimicking nacre. Oyster and mother-of-pearl, like other naturally-tough structures, have a layered structure that accommodates large shear strains. The large fracture toughness of nacre may not be presently practical at macroscale, however, nacre's microstructure can be mimicked to enhance the toughness of the conventional structural composites. Even the smallest improvement in building materials will potentially save lives which are lost in various natural disasters due to low fracture toughness of structures. Work on biomimicked composites conducted in the past included monolithic and reinforced concrete composites using fiber glass for tensile strength. This study examines the use of hemp as a replacement for fiberglass and its effects on the tensile strength and fracture toughness of the resulting composite.

A biological composite found in nature is wood. The ability of a tree to withstand its immense weight, even during high winds, is a testament to its mechanical properties. It owes this to the composite consisting of a natural polymer matrix with cellulose fibers [3]. Another material is Nacre, which is the hard shell of the mollusk mother of pearl. This extraordinary material found in nature consists of ceramics platelets (aragonite) layered together with an organic polymer. This ceramic is $CaCO_3$, a modification of calcium carbonate, has very low fracture toughness but very high stress rating. So by combining this material in layers with an organic matrix it creates a material with a fracture toughness of twenty times that of its ceramic component [3]. The below photos, in Figure 1, are taken by a scanning electron microscope and show the nature of nacre.

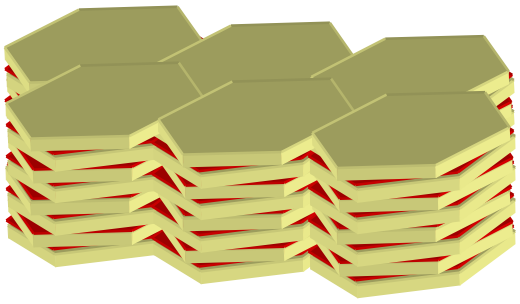

Figure 1- Schematic of layered microstructure of nacre consisting of alternating aragonite platelets (yellow) and natural polymer (red).